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1.3 ATA PO_2-in-He DECOMPRESSION TABLES FOR MK 16 MOD 1 DIVING: SUMMARY REPORT AND OPERATIONAL GUIDANCE

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19. ABSTRACT:

The Navy Experimental Diving Unit (NEDU) was tasked by PMS-EOD to develop repetitive helium-oxygen (HeO_2) decompression tables for use with the MK 16 MOD 1 Underwater Breathing Apparatus. Statistical and probabilistic decompression technology (LEM model) was used to generate profiles with depths, bottom times, and surface intervals of operational relevance to the fleet Explosive Ordnance Disposal (EOD) diver. These profiles were then man-tested 227 times, with one diagnosed case and one possible case of decompression sickness (DCS). These data were used to recalibrate the LEM model, which was then analytically mapped onto a deterministic model to allow the generation of repetitive decompression tables in U.S. Navy Diving Manual format with a predicted risk of DCS of 2.3%. Selected profiles from these tables were man-tested 299 times with 6 cases of DCS, yielding a 2.0% overall observed incidence of DCS in conformance with the intended risk. This report summarizes the work completed at NEDU during the development and testing of these tables, and forwards the tables with recommendations and guidance for their operational use. The tables are recommended for single no-decompression and decompression MK 16 MOD 1 HeO_2 dives to depths from 40 to 300 fsw, and within certain limits, for repetitive MK 16 MOD 1 HeO_2 diving in the 40 to 200 fsw range with surface intervals as short as 30 minutes. A more detailed description of this work will be released in a subsequent report or reports.

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INTRODUCTION

The Navy Experimental Diving Unit (NEDU) was tasked by PMS-EOD to develop repetitive helium-oxygen (HeO_2) decompression tables for use with the MK 16 MOD 1 Underwater Breathing Apparatus (UBA). Statistical and probabilistic decompression technology (LEM model) was used to generate profiles with depths, bottom times, and surface intervals of operational relevance to the fleet Explosive Ordnance Disposal (EOD) diver. These profiles were then man-tested 227 times, with one diagnosed case and one possible case of decompression sickness (DCS). These data were used to recalibrate the LEM model, which was then analytically mapped onto a deterministic model to allow the generation of repetitive decompression tables in U.S. Navy Diving Manual format with a predicted risk of DCS of 2.3%. Selected profiles from these tables were man-tested 299 times with 6 cases of DCS, yielding a 2.0% overall observed incidence of DCS in conformance with the intended risk. This report summarizes the work completed at NEDU during the development and testing of these tables, and forwards the tables with recommendations and guidance for their operational use. The tables are recommended for single no-decompression and decompression MK 16 MOD 1 HeO_2 dives to depths from 40 to 300 feet sea water (fsw), and within certain limits, for repetitive MK 16 MOD 1 HeO_2 diving in the 40 to 200 fsw range with surface intervals as short as 30 minutes. A more detailed description of this work will be released in a subsequent report or reports.

METHODOLOGICAL OVERVIEW

NEDU developed 1.3 ATA PO_2-in-N_2 decompression tables using a modified version of the deterministic model that had been used to produce the 0.7 ATA PO_2-in-N_2 tables currently in the U.S. Navy Diving Manual. A similar modification of the model used to produce the current 0.7 ATA PO_2-in-He tables was used to compute 1.3 ATA PO_2-in-He tables, but schedules in these tables were found to have unacceptably high risks of DCS under the LEM model. Although the LEM model can be used to directly generate tables of pre-specified DCS risk, the parts of such tables that support repetitive diving are extremely difficult to cast in the U.S. Navy Diving Manual format. Therefore, the project was divided into two phases. In Phase I, data on Heliox dives were collected and integrated into the LEM model. The model was then mapped onto a deterministic model that was used to generate repetitive decompression tables in appropriate format. Thirty-seven different single and repetitive dive profiles produced with these tables were then man-tested 299 times in Phase II of the study.

PHASE I: LEM MODEL DEVELOPMENT

Data were collected in Phase I to optimize the LEM model. This was done in a variety of ways. Data from the Defense and Civil Institute of Environmental Medicine (DCIEM, Downsview, Ontario CA) for single 1.3 ATA PO_2-in-He dives and repetitive 1.3 ATA PO_2-in-He dives preceded by three and six hour surface intervals, as well as data from

the Defence Evaluation Research Agency (DERA, Alverstoke U.K.) for single 1.3 ATA PO_2-in-He dives, were obtained and integrated into the LEM model. Unfortunately, there were still no data available for 1.3 ATA PO_2-in-He repetitive dives preceded by surface intervals less than three hours. Therefore, a series of repetitive dive profiles with 30-minute surface intervals was computed using the LEM model and man-tested to obtain data to address this deficiency.

Dives Completed

A total of 227 man-exposures were completed in the NEDU Ocean Simulation Facility (OSF) on 45 different dive profiles. A description of the profiles, with the number of exposures and DCS outcome for each profile, is given in Appendix B.

The first 42 profiles were repetitive dive profiles consisting of two or three dives separated by 30-minute surface intervals. The dives were to depths of 80, 120, 160, or 200 fsw, with bottom times ranging from 15 to 130 minutes. The last three profiles in this program phase were single and repetitive dives to 80 fsw. These dives were completed to obtain a "quick look" at a potentially longer acceptable no-stop limit for MK 16 MOD 1 HeO_2 dives to this depth than prescribed by the LEM model at 2.3% DCS risk. In all profiles, the divers were fully water-immersed and breathed the MK 16 MOD 1 UBA, with 88/12 (%He/%O_2) diluent gas, throughout each dive. All divers performed 50-watt cycle ergometry in approximate 5-minute work/5-minute rest cycles while they were on the bottom. Divers breathed air during all but the last 3 min of any surface interval, when they breathed 0.7 ATA O_2 in He from the MK 16 MOD 1.

Results

One diver who participated in a dive profile consisting of a first dive to 120 fsw for 20 minutes, a 30 minute surface interval, then a second dive to 160 fsw for 20 minutes, reported feeling "dizzy" and exhibited other neurological signs of difficulty with balance when examined within hours of surfacing from the second dive. The case was diagnosed as decompression sickness, but whether the injury involved the vestibular system or the central nervous system could not be determined, even after repeated physical examination, ENT evaluation, and brain imaging. The diver was treated with three U.S. Navy Treatment Table (TT) 6s, and then two TT 9s with full recovery.

One diver experienced transient nausea and vomiting on the bottom in a single dive to 200 fsw for 15 minutes. The remainder of his planned dive profile was aborted. He developed a mild rash on his abdomen several hours after surfacing from the dive. It was not clear that he had DCS, but his case was managed conservatively with administration of a TT 6, during which he experienced rapid recovery.

One diver experienced transient nausea while on the bottom during a single 80 fsw dive for 130 minutes, which resolved spontaneously before surfacing.

LEM MODEL RE-OPTIMIZATION AND TABLE CALCULATION

The dives performed in Phase I of the study provided the only available information about repetitive helium-oxygen diving with surface intervals less than three hours. This information was integrated into the LEM model to improve its accuracy in this operationally critical area. While the LEM model could then be used with confidence to directly compute schedules for repetitive dives, it could not be readily used to produce repetitive dive tables in the format that such tables currently have in the U.S. Navy Diving Manual. In order to produce such tables for MK 16 MOD 1 HeO_2 diving, a method was developed to map the probabilistic LEM model onto a deterministic model similar to that previously used[4] to produce the MK 16 MOD 1 N_2-O_2 tables. The method parameterizes the deterministic model to compute schedules at any pre-specified risk of DCS. The resultant model is then readily used to produce tables for repetitive diving in the desired U.S. Navy Diving Manual format. This method was used to produce the parts of new MK 16 MOD 1 HeO_2 decompression tables in which repetitive diving is supported; i.e., schedules for dives to depths of 200 fsw or less. The remaining parts of the new tables in which repetitive diving is not supported; i.e., schedules for dives to depths of 210 fsw or greater; were computed using LEM directly. All schedules were computed using an acceptable estimated DCS risk of 2.3%. The complete set of final tables is given in Appendix A.

PHASE II: TABLE VALIDATION

Selected profiles from the new MK 16 MOD 1 HeO_2 decompression tables were man-tested in Phase II of the study. Repetitive dives were dived as computed directly by the algorithm used to generate Table 2 of Appendix A; Schedules and Repetitive Group Designators for MK 16 MOD 1 HeO_2 Decompression Dives. Decompressions for these dives were consequently less conservative than those prescribed through use of Table 3 of Appendix A; the MK 16 MOD 1 HeO_2 Surface Interval Credit and Residual Gas Time Table.

Dives Completed

A total of 299 dives on 37 different profiles were completed during this phase. A description of the profiles, with the number of exposures and DCS outcome for each profile, is given in Appendix B.

Each dive profile consisted of one to three dives. The surface intervals in the repetitive dive profiles were either 30 or 180 minutes in duration. The dives were to depths from 100 to 300 fsw with bottom times ranging from 15 to 60 minutes. Total bottom time for any given profile was less than 140 minutes, and the total in-water times for the profiles, including decompression time, but not surface interval time, ranged from approximately 30 to 230 minutes. All divers were fully water-immersed and breathed the MK 16 MOD 1 UBA, with 88/12 (%He/%O_2) diluent gas, throughout each dive. All divers performed 50-watt cycle ergometry in approximate 5-minute work/5-minute rest cycles

while they were on the bottom. Divers breathed air during all but the last 3 min of any surface interval, when they breathed 0.7 ATA O_2 in He from the MK 16 MOD 1.

Because of the concern about oxygen toxicity due to the PO_2 overshoot on descent, a PO_2 breathe-down procedure was adopted from Royal Navy procedures for diving with the Royal Navy MK 16 MOD 1 analog, the Clearance Divers Breathing Apparatus (CDBA). This procedure, which entails repeated inhalation from the rig followed by exhalation into the surrounding air via the Emergency Breathing System (EBS) exhaust until the diver hears his diluent valve firing, was used on dives to depths of 240 fsw and greater. The procedure is performed as described in item 10 of the Conclusions and Recommendations section of this report.

Results

Six cases of DCS were diagnosed in 299 exposures, giving an overall observed DCS incidence of 2.01% (0.74 - 4.32%; 95% binomial confidence limits). This incidence conforms to the 2.3% target DCS risk used in the decompression algorithm to compute the dive profiles.

The six DCS cases had presentations and outcomes as outlined following:

- One diver had shoulder pain and some upper extremity numbness upon surfacing from a dive to 220 fsw for 15 minutes. He was diagnosed with Type II DCS and treated with a TT 6 with complete relief of symptoms.

- Two divers had transient paresthesias, excessive fatigue and decreased mental alertness after completing a three-dive profile in which the deepest dive was to 180 fsw. An additional diver complained simply of excessive fatigue and decreased mental alertness after performing the same profile. Two other divers also complained of excessive fatigue and decreased mental alertness; one after completing a single dive to 200 fsw for 15 minutes, and the other after completing a single dive to 180 fsw for 20 minutes. The excessive fatigue and decreased mental alertness in all of these cases were subtle, subjective complaints that were not accompanied by any objective findings on physical examination. All five of these divers were diagnosed as having Type II DCS, treated with a TT 6, and claimed complete relief of symptoms within minutes of starting treatment.

Other clinically significant dive outcomes occurred as follows:

- One diver felt acutely fatigued and then suffered a loss of consciousness within 30 minutes of surfacing from a single dive to 140 fsw for 30 minutes. He was diagnosed as having AGE, and was treated with a TT 6A and two subsequent TT 9s with complete relief of symptoms.

- One diver experienced an episode of near loss of consciousness while on the bottom in a single dive to 180 fsw for 25 minutes. It is not clear what precipitated

this episode, but the diver's rapid recovery upon ascent suggests that it was a breathing gas problem.

- Finally, two additional divers had post-dive pain that was treated with a TT 6 with minimal relief, motivating final diagnosis of musculo-skeletal injury in each case.

OTHER ISSUES

Diver inspired PO_2 was monitored throughout each dive using mass spectrometric and paramagnetic techniques in order to track diver O_2 exposure and rig performance.

Oxygen Toxicity

The "breathe-down" procedure described in item 10 of the Conclusions and Recommendations section was performed immediately before descent on dives to depths of 240 fsw and deeper in order to mitigate the PO_2 increases that occur during descent on such dives. This breathe-down procedure should only be performed on the surface. No unambiguous cases of O_2 toxicity occurred during either phase of the present study.

UBA Performance

The oxygen sensors in the MK 16 MOD 1 UBA were found to be inaccurate after prolonged use at depth, even if they had been properly calibrated and appeared accurate at one atmosphere. These inaccuracies may explain some or all of the PO_2 fluctuations that were occasionally observed beyond those attributable to PO_2 overshoots accompanying descent. PMS-EOD was informed of the problem and subsequently provided new and improved sensors (Teledyne R10 DN) for testing. Twenty-two dive profiles, 14 of which consisted of repetitive dives, were completed without incident during the last week of the study using these new sensors.

CONCLUSIONS AND RECOMMENDATIONS

1. A complete set of new 1.3 ATA PO_2-in-He decompression tables for MK 16 MOD 1 diving has been developed and tested. These tables, which are given in attached Appendix A, support repetitive diving as per U.S. Navy EOD requirements at an approximate 2.3% risk of DCS. No clear-cut cases of O_2 toxicity were observed during testing.

2. We recommend approval of the attached tables for use with the MK 16 MOD 1 UBA using 88/12 (%He/%O_2) as the diluent gas.

3. Recommended usage is limited to:
   - Single no-decompression and decompression dives to depths of 40 to 300 fsw;
   - No-decompression dives to depths of 40 to 200 fsw followed by up to two repetitive dives preceded by surface intervals no shorter than 30 minutes;
   - Decompression dives to depths of 40 to 200 fsw followed by one repetitive dive after a surface interval no shorter than 30 minutes.

4. If the surface interval preceding a repetitive dive is shorter than 30 minutes, the adjusted bottom time of the repetitive dive should be obtained by adding the bottom time of the previous dive to that of the repetitive dive.

5. Reports of fatigue and decreased mental alertness after otherwise safe completion of helium dives are not uncommon in the literature. Divers should be aware that subtle mental status changes may occur after diving profiles prescribed by the present tables, and that though these changes may affect their ability to carry out assigned duties, the changes are amenable to treatment by standard U.S. Navy DCS treatment tables.

6. An unacceptable incidence of DCS during operational use of any particular dive profile prescribed by these tables will require further study.

7. Selected profiles from these tables have been tested on dives in which the descent rate was less than 60 fpm and the ascent rate was 30 fpm. We recommend that divers using these tables descend at rates no faster than 60 fpm and ascend at 30 fpm.

8. The MK 16 MOD 1 UBA primary display should indicate a transition from 0.7 to 1.3 ATA at 33 fsw. The diver should verify this transition by monitoring his secondary display. If there is no indication of this transition with continued descent past 40 fsw, the dive should be aborted.

9. Under normal conditions, the diver should not add oxygen on descent or at any time while on the bottom due to the increased risk of oxygen toxicity that such practice engenders.

10. The diver should perform the breathe-down procedure immediately before descent on dives to depths of 240 fsw or deeper. This procedure must be performed **only at surface**, because its performance at depth can dangerously deplete the diluent gas supply. The procedure is performed as follows:
    - Diver inhales from the rig and holds breath;
    - While in end-inspiratory breath-hold, diver switches barrel valve on MK 24 Full Face Mask (FFM) or T-bit to closed position;
    - Diver exhales into surrounding water or air and holds his or her breath;
    - Diver switches barrel valve on FFM or T-bit back to UBA gas;
    - Repeat three times or until diluent valve is heard to fire.

11. The MK 16 MOD 1 UBA did not always maintain a mean PO_2 of 1.3 ATA. This was due, at least in part, to problems with the oxygen sensor that have been solved to unknown extent by introduction of new sensors for the rig. Information bearing on improvements in MK 16 MOD 1 UBA performance afforded by these new sensors is forthcoming from a current NEDU program.

12. New analytic technology has been developed to map a probabilistic model into a deterministic algorithm that readily produces decompression tables in U.S. Navy Diving Manual format. This analytic technology can potentially be used to generate different tables for optimizing the balance between DCS risks and other hazards in different EOD operational scenarios. The algorithm produced by this technology is operable in currently available diver-worn dive computers.

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2. Butler, F.K., Thalmann, E.D. "Central Nervous System Oxygen Toxicity in Closed-Circuit SCUBA Divers II." *Undersea Biomed. Res.* 13(2): 193-223. 1986.

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4. Johnson, T.M., Gerth, W.A., Southerland, D.G. *1.3 ATA PO_2 N_2-O_2 Decompression Table Validation.* NEDU TR 9-00, Navy Experimental Diving Unit, Panama City, FL. September 2000.

5. Naval Sea Systems Command, *U. S. Navy Diving Manual,* NAVSEA SS521-AG-PRO-010, Vol. #5, Rev. 4, Table 18-5,18-4. 1999.

APPENDIX A

MK 16 MOD 1 HeO_2 SINGLE AND REPETITIVE DIVE TABLES

Tables 1 to 3 are used to plan single and repetitive dives in precisely the same manner as the Standard Air Tables in the current U.S. Navy Diving Manual. The tables are designed for use with the MK 16 MOD 1 UBA with a PO_2 set point of 1.3 ATA and an 88/12 He/O_2 diluent. All bottom times include the descent time at the designated rate of 60 fsw/min.

Table 1 gives the no-decompression limits and repetitive group designators for no-decompression dives to depths up to 200 fsw. To find the repetitive group designator for a dive, locate the row for the maximum depth of the dive in the left-most column. If there is no entry for the exact dive depth, use the row for the next deeper depth. Then move to the right in the row to the column with the appropriate bottom time (descent time + time on bottom). If the row does not have an entry equal to the exact bottom time, use the column with the next larger time. The repetitive group letter designator for the dive is obtained from the top entry in the column.

Table 2 gives the decompression schedules and surfacing repetitive group designators for decompression dives. Schedules are grouped with solid line separators according to maximum dive depth. A limit line also appears within each group. Only schedules above the limit line in each dive depth group should be used in normal operations. Note that a surfacing repetitive group designator is not given for one or more dives above the limit line in some dive depth groups, indicating that a repetitive dive after such dives is not supported. Schedules below the limit line in each group should be dived only with approval of the on-site commander.

Table 2 is used by locating the row for the intended maximum depth and bottom time for a dive. If exact table entries are not found, use the next deeper depth and the next longer bottom time. Required stops during the decompression are then listed in the columns to the right, with ascent time to first stop, total ascent time (ascent time + time at stops), and the surfacing repetitive group designator for the dive. Stop times are in minutes and do not include ascent times to the stops.

Table 3 gives surface interval credits (top) and residual gas times (bottom) for use in planning repetitive MK 16 MOD 1 HeO_2 dives after designated times at surface. All times in the body of the top Surface Interval Credit table show the elapsed time in ranges of hours:minutes after surfacing. All elapsed times were computed assuming air breathing at surface, but any N_2-O_2 mix with PO_2 in excess of 0.21 ATA may be breathed.

Table 3 is used by locating the row in the Surface Interval Credit table for the surfacing repetitive group designator from the last completed dive, as obtained from Table 1 if the dive was a no-decompression dive, or from Table 2 if the dive was a decompression dive. Then the column to the right along this row with entry equal to or just greater than the actual or planned time at surface is found. The end-interval, or final, repetitive group

designator is read from the bottom of this column. A column directly below this column in the Residual Gas Time Table gives residual gas times for this final repetitive group for MK 16 MOD 1 HeO_2 repetitive dives. In order to determine the residual gas time for such a dive, locate the row in the latter table for the maximum depth of the planned repetitive dive. The entry along this row in the column for the end-interval, or final, repetitive group designator is the residual gas time in minutes. This residual gas time is added to the bottom time for the planned repetitive dive to obtain an equivalent single dive bottom time. The equivalent single dive bottom time and the planned maximum dive depth are then used to locate the appropriate decompression schedule and surfacing repetitive group designator for the repetitive dive in Table 1 or 2.

A Repetitive Dive Worksheet for MK 16 MOD 1 HeO_2 dives is provided to assist with these calculations.

Limit Lines

Table 2 contains limit lines in the each of the dive depth groups. Schedules below the limit line in each group should not be used in normal operations. Limit lines are placed according the same rule to limit O_2 exposure used to place limit lines in the constant 1.3 ATA PO_2-in-N_2 tables.[4]

In order to limit O_2 toxicity risks during MK 25 MOD 0, MOD 1 and MOD 2 (Draeger LAR V UBA) diving, the current U.S. Navy Diving Manual limits the duration of such dives to 240 min at 25 fsw,[5] in accord with studies completed by Butler and Thalmann.[2,3] This limit is shortened if the dive includes short excursions to deeper depths. Diver inspired PO_2 while breathing the MK 25 varies with the purge procedure used prior to beginning the dive.[1] Using the recommended Single Fill/Empty Cycle (SFE) purge procedure, an average oxygen fraction of 74% is attained, which changes little throughout the course of the ensuing dive. This fraction corresponds to an inspired PO_2 of 1.3 ATA at 25 fsw. Therefore, in order to remain consistent with the sustained O_2 exposure limits for the MK 25 UBA, limit lines in the present MK 16 MOD 1 HeO_2 decompression table (Table 3) are placed to allow total dive times no longer than 240 min. Note that in considering bottom times up to 720 min in Table 1, the table gives repetitive dive groups for no-stop dives that are prohibited under this recommendation. (It should also be noted that the U.S. Navy Diving Manual imposes no limit for breathing 1.3 ATA PO_2 in surface supplied HeO_2 diving operations. However, this lack of constraint is not applicable to MK 16 dives because, unlike MK 16 dives, surface supplied HeO_2 dives are undertaken with full helmet and communications with the surface.)

Table 1. No-Decompression Limits and Repetitive Group Designators for MK 16 MOD 1 HeO_2 No-Decompression Dives

1.30 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 30 FPM

NO-DECOMPRESSION DIVES

DEPTH (FSW)	NO-STOP LIMIT	REPETITIVE GROUP DESIGNATOR BOTTOM TIME (MIN)														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
20	720	129	269	720													
30	332	27	43	60	78	100	124	152	185	227	281	332					
40	720	122	246	720													
50	325	27	43	59	78	99	123	150	183	223	276	325					
60	134	15	23	32	41	51	61	71	83	95	108	123	134				
70	86	11	16	22	28	34	41	47	54	61	69	77	85	86			
80	63	8	12	17	21	26	30	35	40	45	51	56	62	63			
90	44	6	10	13	17	20	24	28	32	36	40	44					
100	31	5	8	11	14	17	20	23	26	30	31						
110	24	4	7	9	12	14	17	20	22	24							
120	20	4	6	8	10	13	15	17	19	20							
130	17	3	5	7	9	11	13	15	17								
140	15	3	4	6	8	10	12	13	15								
150	13	3	4	6	7	9	10	12	13								
160	12		3	5	6	8	9	11	12								
170	11		3	4	6	7	9	10	11								
180	10		3	4	5	6	8	9	10								
190	9		3	4	5	6	7	8	9								
200	8			3	4	5	7	8									

Table 2. Schedules and Repetitive Group Designators for MK 16 MOD 1 HeO_2 Decompression Dives

1.30 ATA FIXED PO2 IN HELIUM — RATES: DESCENT 60 FPM; ASCENT 30 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
40	238	1:20														0	0	1:20	B
limit line																			
40	720	1:20														0	0	1:20	C
50	238	1:40														0	0	1:40	J
limit line																			
50	325	1:40														0	0	1:40	K
50	330	1:00														1	0	2:40	K
50	340	1:00														2	0	3:40	K
50	350	1:00														3	0	4:40	K
50	360	1:00														4	0	5:40	K
60	134	2:00														0	0	2:00	L
60	140	1:20														3	0	5:00	L
60	150	1:20														8	0	10:00	L
60	160	1:20														12	0	14:00	L
60	170	1:20														16	0	18:00	L
60	180	1:20														20	0	22:00	K
60	190	1:20														24	0	26:00	K
60	200	1:20														27	0	29:00	K
limit line																			
60	210	1:20														31	0	33:00	K
60	220	1:20														34	0	36:00	K
60	230	1:20														37	0	39:00	J
60	240	1:20														39	0	41:00	J
60	250	1:20														42	0	44:00	J
60	260	1:20														45	0	47:00	J
60	270	1:20														47	0	49:00	J
60	280	1:20														49	0	51:00	J

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
60	290	1:20														51	0	53:00	J
60	300	1:20														53	0	55:00	J
60	310	1:20														55	0	57:00	J
60	320	1:20														57	0	59:00	I
60	330	1:20														59	0	61:00	I
60	340	1:20														61	0	63:00	I
60	350	1:20														64	0	66:00	I
60	360	1:20														66	0	68:00	I
70	86	2:20														0	0	2:20	M
70	90	1:40														3	0	5:20	M
70	95	1:40														7	0	9:20	L
70	100	1:40														12	0	14:20	L
70	110	1:40														19	0	21:20	L
70	120	1:40														26	0	28:20	L
70	130	1:40														33	0	35:20	K
70	140	1:40														39	0	41:20	K
70	150	1:40														45	0	47:20	K
70	160	1:40														50	0	52:20	K
70	170	1:40														55	0	57:20	J
limit line																			
70	180	1:40														60	0	62:20	J
70	190	1:40														64	0	66:20	J
70	200	1:40														68	0	70:20	J
70	210	1:40														72	0	74:20	J
70	220	1:40														76	0	78:20	I
80	63	2:40														0	0	2:40	M
80	65	2:00														2	0	4:40	M
80	70	2:00														8	0	10:40	L
80	75	2:00														13	0	15:40	L
80	80	2:00														19	0	21:40	L
80	85	2:00														24	0	26:40	L

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
80	90	2:00														29	0	31:40	L
80	95	2:00														34	0	36:40	L
80	100	2:00														39	0	41:40	K
80	110	2:00														47	0	49:40	K
80	120	2:00														56	0	58:40	K
80	130	2:00														63	0	65:40	K
80	140	2:00														70	0	72:40	J
80	150	2:00														76	0	78:40	J
limit line ----------																			
80	160	2:00														82	0	84:40	J
80	170	2:00														88	0	90:40	J
80	180	2:00														93	0	95:40	I
80	190	2:00														98	0	100:40	I
90	44	3:00														0	0	3:00	K
90	45	2:20														1	0	4:00	K
90	50	2:20														2	0	5:00	L
90	55	2:20														7	0	10:00	M
90	60	2:20														15	0	18:00	L
90	65	2:20														22	0	25:00	L
90	70	2:20														29	0	32:00	L
90	75	2:20														35	0	38:00	L
90	80	2:20														41	0	44:00	L
90	85	2:20														47	0	50:00	K
90	90	2:20														53	0	56:00	K
90	95	2:20														58	0	61:00	K
90	100	2:20														63	0	66:00	K
90	110	2:20														73	0	76:00	J
90	120	2:20														82	0	85:00	J
90	130	2:20														90	0	93:00	J
limit line ----------																			

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
90	140	2:20														97	0	100:00	J
90	150	2:20														104	0	107:00	J
90	160	2:20														112	0	115:00	I
100	31	3:20														0	0	3:20	J
100	35	2:40														2	0	5:20	K
100	40	2:40														4	0	7:20	L
100	45	2:40														6	0	9:20	M
100	50	2:40														16	0	19:20	L
100	55	2:40														24	0	27:20	L
100	60	2:40														33	0	36:20	L
100	65	2:40														40	0	43:20	L
100	70	2:40														48	0	51:20	K
100	75	2:40														55	0	58:20	K
100	80	2:40														62	0	65:20	K
100	85	2:40														68	0	71:20	K
100	90	2:40														74	0	77:20	K
100	95	2:40														80	0	83:20	J
100	100	2:40														85	0	88:20	J
100	110	2:40														96	0	99:20	J
100	120	2:40														105	0	108:20	J
limit line																			
100	130	2:20														1 114	0	118:36	I
100	140	2:20														1 123	0	127:36	I
110	24	3:40														0	0	3:40	I
110	25	3:00														1	0	4:40	I
110	30	3:00														4	0	7:40	J
110	35	3:00														7	0	10:40	L
110	40	3:00														10	0	13:40	M
110	45	3:00														21	0	24:40	L
110	50	3:00														31	0	34:40	L
110	55	3:00														40	0	43:40	L

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
110	60	2:40													1	49	0	53:40	K
110	65	2:40													2	56	0	61:40	K
110	70	2:40													3	63	0	69:40	K
110	75	2:40													4	70	0	77:40	K
110	80	2:40													5	77	0	85:40	J
110	85	2:40													5	83	0	91:40	J
110	90	2:40													6	89	0	98:40	J
110	95	2:40													6	95	0	104:40	J
110	100	2:40													6	101	0	110:40	J
110	110	2:40													7	111	0	121:40	J
limit line																			
110	120	2:40													7	123	0	133:40	
110	130	2:40													7	136	0	146:56	
110	140	2:20												1	7	148	0	159:56	
120	20	4:00														0	0	4:00	I
120	25	3:20														4	0	8:00	J
120	30	3:20														8	0	12:00	K
120	35	3:20														12	0	16:00	M
120	40	3:20														23	0	27:00	L
120	45	3:00													2	33	0	39:00	L
120	50	3:00													4	43	0	51:00	L
120	55	3:00													6	51	0	61:00	K
120	60	3:00													7	60	0	71:00	K
120	65	2:40												1	7	68	0	80:00	K
120	70	2:40												2	7	76	0	89:00	K
120	75	2:40												3	7	83	0	97:00	J
120	80	2:40												4	7	90	0	105:00	J
120	85	2:40												5	7	97	0	113:00	J
120	90	2:40												5	7	103	0	119:00	J
120	95	2:40												6	7	109	0	126:00	J
120	100	2:40												6	7	116	0	133:00	
limit line																			

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
120	110	2:40												6	7	130	0	147:00	
120	120	2:40												7	7	145	0	163:00	
130	17	4:20															0	0 4:20	H
130	20	3:40															3	0 7:20	I
130	25	3:40															8	0 12:20	K
130	30	3:40															13	0 17:20	L
130	35	3:20														2	21	0 27:20	L
130	40	3:20														5	32	0 41:20	L
130	45	3:00													1	7	42	0 54:20	L
130	50	3:00													3	7	53	0 67:20	K
130	55	3:00													5	7	62	0 78:20	K
130	60	3:00													6	7	71	0 88:20	K
130	65	2:40												1	7	7	80	0 99:20	J
130	70	2:40												2	7	7	88	0 108:20	J
130	75	2:40												3	7	7	96	0 117:20	J
130	80	2:40												3	7	7	104	0 125:20	J
130	85	2:40												4	7	7	111	0 133:20	J
130	90	2:40												5	7	7	118	0 141:20	
limit line																			
130	95	2:40												5	7	7	126	0 149:20	
130	100	2:40												5	8	7	135	0 159:20	
130	110	2:40												6	7	7	151	0 175:20	
130	120	2:40												7	7	18	158	0 194:20	
140	15	4:40															0	0 4:40	H
140	20	4:00															7	0 11:40	J
140	25	4:00															12	0 16:40	K
140	30	3:40														2	16	0 22:40	M
140	35	3:40														7	28	0 39:40	L
140	40	3:20													3	7	41	0 55:40	L
140	45	3:20													6	7	52	0 69:40	K
140	50	3:00												1	7	7	63	0 82:40	K

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
140	55	3:00											3	7	7	74	0	95:40	K
140	60	3:00											5	7	7	83	0	106:40	J
140	65	3:00											7	7	7	92	0	117:40	J
140	70	2:40										1	7	7	7	101	0	127:40	J
140	75	2:40										2	7	7	7	109	0	136:40	J
140	80	2:40										3	7	7	7	117	0	145:40	
limit line ----------																			
140	85	2:40										3	8	7	7	126	0	155:40	
140	90	2:40										4	7	7	7	137	0	166:40	
140	95	2:40										5	7	7	7	146	0	176:40	
140	100	2:40										5	7	7	8	154	0	185:40	
150	13	5:00														0	0	5:00	H
150	15	4:20														3	0	8:00	H
150	20	4:20														10	0	15:00	J
150	25	4:00													2	14	0	21:00	L
150	30	4:00													7	23	0	35:00	L
150	35	3:40												4	7	37	0	53:00	L
150	40	3:20											1	7	7	50	0	70:00	K
150	45	3:20											4	7	7	63	0	86:00	K
150	50	3:20											7	7	7	74	0	100:00	K
150	55	3:00										2	7	7	7	85	0	113:00	J
150	60	3:00										4	7	7	7	95	0	125:00	J
150	65	3:00										6	7	7	7	104	0	136:16	J
150	70	3:00										7	7	7	7	114	0	147:00	I
150	75	2:40									1	7	7	7	7	124	0	158:16	
limit line ----------																			
150	80	2:40									2	7	7	7	7	135	0	170:16	
150	85	2:40									3	7	7	7	7	146	0	182:16	
150	90	2:40									4	7	7	7	8	155	0	193:00	

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
160	12	5:20														0	0	5:20	H
160	15	4:40														5	0	10:20	I
160	20	4:40														13	0	18:20	K
160	25	4:20													6	15	0	26:20	M
160	30	4:00												4	7	31	0	47:20	L
160	35	3:40											2	7	7	46	0	67:20	L
160	40	3:40											6	7	7	60	0	85:20	K
160	45	3:20										2	8	7	7	73	0	102:20	J
160	50	3:20										5	7	7	8	84	0	116:20	J
160	55	3:00									1	7	7	7	7	96	0	130:20	J
160	60	3:00									3	7	7	7	7	107	0	143:20	J
160	65	3:00									5	7	7	7	7	117	0	155:36	
160	70	3:00									6	7	7	7	7	129	0	168:36	
limit line																			
160	75	3:00									7	7	8	7	7	141	0	182:36	
160	80	2:40								1	7	8	7	7	7	153	0	195:20	
160	85	2:40								2	7	7	7	7	16	157	0	208:36	
160	90	2:40								3	7	7	7	7	25	161	0	222:36	
170	11	5:40														0	0	5:40	H
170	15	5:00														8	0	13:40	I
170	20	4:40													2	15	0	22:40	K
170	25	4:20												2	7	22	0	36:40	L
170	30	4:00											1	8	7	38	0	59:40	L
170	35	4:00											7	7	7	55	0	81:40	K
170	40	3:40										4	7	7	7	70	0	100:40	K
170	45	3:20									1	7	7	7	7	83	0	117:40	J
170	50	3:20									4	7	7	7	7	96	0	133:40	J
170	55	3:20									7	7	7	7	7	108	0	148:40	J
170	60	3:00								2	7	7	7	7	7	119	0	161:40	
limit line																			
170	65	3:00								4	7	7	7	7	7	134	0	178:56	
170	70	3:00								5	7	7	7	7	8	146	0	192:40	

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
170	75	3:00								7	7	7	7	7	11	156	0	207:56	
170	80	2:40							1	7	7	7	7	7	22	160	0	223:40	
180	10	6:00														0	0	6:00	H
180	15	5:20														11	0	17:00	J
180	20	5:00													6	14	0	26:00	L
180	25	4:40												6	7	29	0	48:00	L
180	30	4:20											6	7	7	47	0	73:00	K
180	35	4:00										4	7	7	7	64	0	95:00	K
180	40	3:40									2	7	7	7	7	79	0	115:00	J
180	45	3:40									6	7	7	7	7	94	0	134:00	J
180	50	3:20								2	7	8	7	7	7	107	0	151:00	J
180	55	3:20								5	7	7	7	7	8	119	0	166:00	
limit line																			
180	60	3:00							1	7	7	7	7	7	7	136	0	185:00	
180	65	3:00							3	7	7	7	7	7	7	151	0	202:16	
180	70	3:00							5	7	7	7	7	7	16	158	0	220:00	

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)	RPT GRP DES
190	9	6:20																0	0	6:20	H
190	10	5:40																2	0	8:20	H
190	15	5:40																14	0	20:20	J
190	20	4:40													1	1	7	16	0	31:20	M
190	25	3:20									1	0	0	0	2	7	7	37	0	60:20	L
190	30	3:00								1	0	0	1	1	7	7	7	56	0	86:20	K
190	35	2:40							1	0	0	1	0	7	7	7	7	74	0	110:20	J
190	40	2:20						1	0	0	0	1	5	7	7	8	7	90	0	132:20	J
190	45	2:20						1	0	0	0	4	7	7	7	7	7	105	0	151:20	J
190	50	2:20						1	0	0	0	7	7	7	7	7	7	119	0	168:20	I
limit line																					
190	55	2:20						1	0	0	3	7	7	7	7	7	7	137	0	189:20	
190	60	2:20						1	0	0	6	7	7	7	7	7	7	153	0	208:20	
190	65	2:20						1	0	1	7	7	7	7	7	7	19	159	0	228:36	
190	70	2:20						1	0	3	7	7	7	7	7	7	31	164	0	247:20	
200	8	6:40																	0	6:40	G
200	10	6:00																4	0	10:40	I
200	15	5:20														1	1	14	0	22:40	K
200	20	3:20								1	0	0	1	0	0	4	7	24	0	43:40	L
200	25	2:00				1	0	0	0	1	0	0	0	1	6	7	7	47	0	76:40	K
200	30	1:20		1	0	0	1	0	0	0	1	0	0	7	7	7	7	68	0	105:40	K
200	35	1:20		1	0	1	0	0	0	1	0	0	6	7	7	7	7	87	0	130:40	J
200	40	1:00	1	0	1	0	0	0	1	0	0	4	7	7	7	7	7	104	0	152:40	J
200	45	1:00	1	0	1	0	0	1	0	0	1	7	8	7	7	7	7	120	0	173:40	I
limit line																					
200	50	1:00	1	0	1	0	0	1	0	0	5	7	7	7	7	7	7	139	0	195:40	
200	55	1:00	1	0	1	0	0	1	0	1	7	7	7	7	7	7	8	155	0	215:40	
200	60	1:00	1	0	1	0	0	1	0	4	7	7	7	7	7	7	23	160	0	238:40	

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
210	5	7:00															7:00
210	10	6:00												2	2	0	11:00
210	15	5:00									1	1	3	2	5	0	19:00
210	20	4:40								2	3	2	2	2	28	0	46:00
210	25	4:00						1	3	2	2	3	1	3	57	0	79:00
210	30	3:40					1	3	2	2	2	3	4	12	76	0	112:00
210	35	3:20				1	2	3	2	2	2	6	11	12	95	0	143:00
210	40	3:20				3	2	2	2	2	5	12	11	11	113	0	170:00
limit line																	
210	45	3:00			1	3	2	2	3	2	12	11	12	11	130	0	196:00
210	50	3:00			2	2	2	3	2	9	12	11	11	11	148	0	220:00
210	55	3:00			3	2	2	2	6	11	11	11	11	12	165	0	243:00
210	60	2:40		1	2	3	1	3	10	11	11	11	11	20	173	0	264:00
220	5	7:20														0	7:20
220	10	6:00											1	2	2	0	12:20
220	15	5:20									2	2	2	3	5	0	21:20
220	20	4:40							2	2	2	3	2	2	36	0	56:20
220	25	4:00					1	2	2	2	3	2	2	8	64	0	93:20
220	30	3:40				1	3	2	2	2	3	2	10	11	85	0	128:20
220	35	3:20			1	2	2	3	3	1	2	11	12	12	104	0	160:20
220	40	3:20			2	3	2	2	2	3	11	11	11	11	124	0	189:20
limit line																	
220	45	3:00		1	2	3	2	2	2	10	11	11	11	12	143	0	217:20
220	50	3:00		2	2	2	3	2	7	11	11	11	11	12	162	0	243:20
220	55	3:00		2	3	2	2	4	11	11	11	11	11	19	174	0	268:20

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
230	5	7:40														0	7:40
230	10	6:20											1	3	2	0	13:40
230	15	5:20								1	2	2	2	3	8	0	25:40
230	20	4:40						1	2	2	3	2	2	2	46	0	67:40
230	25	4:20					2	3	2	3	2	2	2	12	71	0	106:40
230	30	3:40			1	2	2	2	3	2	2	6	12	11	93	0	143:40
230	35	3:20		1	2	2	2	3	2	2	7	12	12	12	114	0	178:40
limit line																	
230	40	3:20		2	2	3	2	2	2	8	11	12	11	11	136	0	209:40
230	45	3:00	1	2	2	3	2	2	7	12	10	11	11	12	157	0	239:40
230	50	3:00	2	2	2	2	3	4	12	11	11	11	11	16	173	0	267:40
230	55	3:00	2	3	2	3	2	10	11	11	11	11	11	37	172	0	293:40
240	5	8:00														0	8:00
240	10	6:40											2	3	3	0	16:00
240	15	5:40								2	2	2	3	2	16	0	35:00
240	20	5:00						2	3	2	2	2	3	2	54	0	78:00
240	25	4:20				2	2	3	2	2	3	2	7	11	79	0	121:00
240	30	4:00			3	2	2	2	2	3	2	11	12	11	103	0	161:00
240	35	3:40		3	2	2	3	1	3	3	12	11	12	11	126	0	197:00
limit line																	
240	40	3:20	2	2	3	2	2	2	4	12	11	11	11	12	149	0	231:00
240	45	3:20	3	3	1	3	2	4	11	11	12	11	11	12	171	0	263:00
240	50	3:20	4	2	2	2	3	11	11	11	11	11	11	33	173	0	293:00

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
250	5	8:20														0	8:20
250	10	6:40										1	2	2	4	0	17:20
250	15	5:40							1	2	2	3	3	1	24	0	44:20
250	20	5:00					2	2	2	2	3	2	3	5	61	0	90:20
250	25	4:20			1	3	2	2	2	2	3	2	12	12	86	0	135:20
250	30	4:00		2	3	2	2	2	2	3	6	12	12	12	111	0	177:20
limit line																	
250	35	3:40	2	2	3	2	2	2	2	10	11	12	11	11	137	0	215:20
250	40	3:40	4	2	3	2	2	2	11	11	11	11	11	11	163	0	252:20
250	45	3:40	5	3	2	2	2	10	12	11	11	11	11	25	173	0	286:20
250	50	3:40	6	2	2	3	9	11	11	12	10	12	11	47	174	0	318:20
260	5	8:40														0	8:40
260	10	7:00										2	2	2	4	0	18:40
260	15	6:00							2	2	3	2	2	3	31	0	53:40
260	20	5:00				1	2	2	3	2	3	2	2	10	67	0	102:40
260	25	4:40			3	3	2	2	2	2	2	7	12	12	95	0	150:40
260	30	4:00	2	2	3	2	2	2	2	3	11	12	12	10	123	0	194:40
limit line																	
260	35	4:00	4	2	2	3	2	2	6	11	12	11	11	11	150	0	235:40
260	40	4:00	6	2	2	2	3	7	11	12	11	11	11	13	175	0	274:40
260	45	4:00	7	2	3	2	7	12	11	11	11	11	11	42	172	0	310:40

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
270	5	8:20													1	0	10:00
270	10	7:00									1	2	2	3	4	0	21:00
270	15	6:00						1	2	3	2	3	2	2	39	0	63:00
270	20	5:20				3	2	2	3	2	2	2	4	12	74	0	115:00
270	25	4:40	0	3	2	2	2	2	3	2	3	11	11	12	103	0	165:00
270	30	4:20	4	2	2	2	2	3	3	7	11	11	12	11	133	0	212:00
limit line																	
270	35	4:20	6	2	2	3	2	3	10	12	11	11	11	11	163	0	256:00
270	40	4:20	8	2	2	2	5	11	11	12	10	11	11	29	175	0	298:00
270	45	4:20	9	3	2	4	12	11	11	11	11	11	11	56	175	0	336:00
280	5	8:40													1	0	10:20
280	10	7:40										4	2	3	5	0	23:20
280	15	6:20						3	2	2	2	3	2	2	47	0	72:20
280	20	5:20			1	3	3	2	2	3	1	2	9	12	80	0	127:20
280	25	4:40	1	3	2	3	2	2	3	2	7	11	12	11	113	0	181:20
limit line																	
280	30	4:40	5	3	2	2	3	2	3	12	11	11	11	12	144	0	230:20
280	35	4:40	8	2	2	2	3	7	12	12	10	11	11	12	176	0	277:20
280	40	4:40	10	2	2	3	10	11	11	11	11	11	11	44	175	0	321:20
280	45	4:40	11	2	3	11	11	11	11	11	11	11	11	71	178	0	362:20
290	5	8:40												1	1	0	11:40
290	10	8:00										4	3	3	5	0	24:40
290	15	6:20					2	2	2	3	2	2	2	3	54	0	81:40
290	20	5:40			3	3	2	2	2	3	2	3	12	11	88	0	140:40
290	25	5:00	4	2	2	2	3	3	1	2	12	11	12	11	121	0	195:40
limit line																	

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
290	30	5:00	7	2	3	2	2	3	8	11	12	11	11	11	156	0	248:40
290	35	5:00	10	2	2	2	4	12	11	11	11	11	11	27	175	0	298:40
290	40	5:00	12	2	2	7	12	11	11	11	11	10	11	58	178	0	345:40
290	45	5:00	13	3	8	11	11	11	12	12	9	10	19	82	179	0	389:40
300	5	9:00												1	2	0	13:00
300	10	7:40								1	3	2	2	3	7	0	28:00
300	15	6:40					3	2	2	3	2	2	2	5	60	0	91:00
300	20	5:40		1	4	2	2	3	2	2	2	7	12	12	95	0	154:00
300	25	5:20	5	3	2	2	2	2	3	6	12	11	12	11	131	0	212:00
limit line																	
300	30	5:20	9	2	2	3	2	4	12	11	11	11	11	12	168	0	268:00
300	35	5:20	12	2	2	2	10	11	12	11	10	11	11	41	177	0	322:00
300	40	5:20	14	2	4	11	11	11	11	11	11	11	11	73	180	0	371:00
limit line																	
310	6	9:00											1	3	2	0	16:20
310	10	8:00								3	2	2	2	3	14	0	36:20
310	15	6:40				1	3	2	3	2	3	1	3	8	65	0	101:20
310	20	6:00		4	3	2	2	2	3	2	2	11	12	11	103	0	167:20
310	25	5:40	7	3	1	3	2	2	3	11	11	11	11	12	141	0	228:20
310	30	5:40	11	2	2	2	3	9	11	12	11	11	11	16	177	0	288:20
310	35	5:40	14	2	2	6	11	12	11	11	11	10	11	54	179	0	344:20
310	40	5:40	16	2	10	11	11	11	12	11	9	11	19	82	182	0	397:20
limit line																	
320	6	9:00										1	1	2	3	0	17:40
320	10	8:00							1	3	2	2	3	2	20	0	43:40

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS STOP TIMES (MIN)													TOTAL ASCNT TIME (M:S)
			140	130	120	110	100	90	80	70	60	50	40	30	20	10	
320	15	7:00				3	3	2	2	2	2	3	2	12	70	0	111:40
320	20	6:00	1	5	2	3	1	3	3	1	6	11	12	12	110	0	180:40
320	25	6:00	9	2	2	3	2	2	6	12	11	11	11	12	152	0	245:40
320	30	6:00	13	2	2	2	6	11	11	11	11	11	11	29	178	0	308:40
320	35	6:00	15	3	2	11	12	11	11	11	10	11	11	68	182	0	368:40
320	40	6:00	18	7	11	11	11	11	10	11	11	12	36	83	182	0	424:40

Table 3. MK 16 MOD 1 HeO_2 Surface Interval Credit and Residual Gas Time Table

START															
A															2:01
B														1:10	3:11
C													0:50	2:00	4:01
D												0:42	1:32	2:43	4:44
E											0:42	1:25	2:15	3:25	5:26
F										0:42	1:25	2:07	2:57	4:08	6:08
G									0:42	1:25	2:07	2:49	3:39	4:50	6:51
H								0:42	1:25	2:07	2:49	3:32	4:22	5:32	7:33
I							0:42	1:25	2:07	2:49	3:32	4:14	5:04	6:15	8:15
J						0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:46	6:57	8:58
K					0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:29	7:39	9:40
L				0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:21	7:11	8:22	10:22
M			0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:21	7:03	7:53	9:04	11:05
N		0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:21	7:03	7:46	8:36	9:46	11:47
O	0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:21	7:03	7:46	8:28	9:18	10:29	12:29
Z	0:42	1:25	2:07	2:49	3:32	4:14	4:56	5:39	6:21	7:03	7:46	8:28	9:10	10:00	11:11	13:12

FINAL	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

REPETS BREATHING 1.30 ATA FIXED PO2 IN HELIUM

DEPTH																
10																720
20														720	269	129
30				720	516	362	281	227	185	152	124	100	78	60	43	27
40														720	246	122
50				720	490	352	276	223	183	150	123	99	78	59	43	27
60	220	195	174	155	138	123	108	95	83	71	61	51	41	32	23	15
70	123	112	103	94	85	77	69	61	54	47	41	34	28	22	16	11
80	86	80	74	67	62	56	51	45	40	35	30	26	21	17	12	8
90	67	62	57	53	48	44	40	36	32	28	24	20	17	13	10	6
100	54	51	47	43	40	36	33	30	26	23	20	17	14	11	8	5
110	46	43	40	37	34	31	28	25	22	20	17	14	12	9	7	4
120	40	37	34	32	29	27	24	22	19	17	15	13	10	8	6	4
130	35	32	30	28	26	24	21	19	17	15	13	11	9	7	5	3
140	31	29	27	25	23	21	19	17	15	13	12	10	8	6	4	3
150	28	26	24	22	21	19	17	15	14	12	10	9	7	6	4	3
160	25	24	22	20	19	17	16	14	12	11	9	8	6	5	3	3
170	23	22	20	19	17	16	14	13	11	10	9	7	6	4	3	3
180	21	20	19	17	16	14	13	12	10	9	8	6	5	4	3	3
190	20	18	17	16	15	13	12	11	10	8	7	6	5	4	3	3
200	18	17	16	15	13	12	11	10	9	8	7	5	4	3	3	3

REPETITIVE DIVE WORKSHEET FOR MK 16 MOD 1 HeO_2 DIVES

Part 1 Previous Dive:

_____ minutes
_____ feet
_____ repetitive group designator from Table 1 if the dive was a no-decompression dive, or from Table 2 if the dive was a decompression dive

Part 2. Surface Interval:

Enter the top section of Table 3 at the row for the repetitive group designator from Part 1 and move horizontally to the right to the column in which the time equal to or just greater than the actual or planned surface interval time lies. Read the final repetitive group designator from the bottom of this column.

_____ hours _____ minutes on the surface

_____ final repetitive group from Table 3

Part 3. Equivalent Single Dive Time for the Repetitive Dive:

Enter the bottom section of Table 3 at the row for the maximum depth of the planned repetitive dive. Move horizontally to the right to the column of the final repetitive group designator from Part 2 to find the Residual Gas Time (RGT). Add this RGT to the planned bottom time for the repetitive dive to obtain the equivalent single dive time.

_____ minutes: RGT

+_____ minutes: planned bottom time

=_____ minutes: equivalent single dive time

Part 4. Decompression Schedule for the Repetitive Dive:

Locate the row for the depth of the planned repetitive dive in Table 1. Move horizontally to the right to the column with bottom time equal to or just greater than the equivalent single dive time and read the surfacing repetitive group for the repetitive dive from the top of the column. If the equivalent single dive time exceeds the no-decompression limit, locate the row for the depth and equivalent single dive time in Table 2. Read the required decompression stops and surfacing repetitive group from the columns to the right along this row.

_____ minutes: equivalent single dive time from Part 3

_____ feet: depth of the repetitive dive

_____ Schedule (depth/bottom time) from Table 2, if a decompression dive

APPENDIX B

TEST DIVES COMPLETED

The dive profiles tested in Phases I and II of the study are listed in the following table, where "- SI30 -" indicates a 30 minute surface interval; or "-SI180-" indicates a 180 minute surface interval. Divers breathed air during all but the last 3 min of any surface interval, when they breathed 0.7 ATA O_2 in He from the MK 16 MOD 1. Any required decompression stops (Depth/Stop time) are listed in order of decreasing depth under each dive. The dive numbers range from one to five, depending on the number of repetitive dives in the profile. All depths are in fsw and all times are in minutes. Bottom times include descent time. Ascent times to stops are not included in the stop times. The number of exposures and number of DCS cases on each profile are in the two right-most columns.

Phase I.

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
1	160/ 25 50/ 2 40/ 2 30/ 3 20/ 6	- SI30 -	160/ 25 50/ 2 40/ 3 30/ 4 20/ 79			2	1
2	120/ 20	- SI30 -	160/ 15 30/ 2 20/ 14	- SI30 -	160/ 20 40/ 2 30/ 3 20/ 65	3	0
3	200/ 15 50/ 1 40/ 2 30/ 3 20/ 4	- SI30 -	160/ 15 30/ 2 20/ 36	- SI30 -	160/ 15 30/ 1 20/ 49	4	0
4	200/ 15 50/ 1 40/ 2 30/ 3 20/ 4	- SI30 -	200/ 20 70/ 2 60/ 2 50/ 2 40/ 3 30/ 12 20/ 73			3	0
5-B	200/ 22 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 2 20/ 47	- SI30 -	160/ 15 30/ 1 20/ 49			4	0
6-B	120/ 15	- SI30 -	200/ 23 80/ 2 70/ 3 60/ 2 50/ 2 40/ 2 30/ 12 20/ 71			4	0
7-B	160/ 15 30/ 1 20/ 2	- SI30 -	200/ 23 80/ 2 70/ 3 60/ 2 50/ 3 40/ 7 30/ 12 20/ 81			4	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
8-B	120/ 15	- SI30 -	160/ 20 40/ 2 30/ 2 20/ 23	- SI30 -	120/ 21 20/ 52	4	0
9-B	120/ 19 20/ 2	- SI30 -	120/ 15 20/ 2	- SI30 -	200/ 15 50/ 2 40/ 2 30/ 3 20/ 68	4	0
10-B	160/ 20 40/ 2 30/ 2 20/ 4	- SI30 -	120/ 15 20/ 13	- SI30 -	160/ 17 40/ 2 30/ 3 20/ 65	4	0
11-B	200/ 22 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 2 20/ 47	- SI30 -	120/ 20 20/ 40			4	0
12-B	120/ 15	- SI30 -	160/ 15 30/ 2 20/ 14	- SI30 -	200/ 15 50/ 2 40/ 2 30/ 2 20/ 69	4	0
13-B	160/ 20 40/ 2 30/ 2 20/ 4	- SI30 -	200/ 18 70/ 2 60/ 2 50/ 2 40/ 2 30/ 12 20/ 72			4	1
14-B	200/ 15 50/ 1 40/ 2 30/ 3 20/ 4	- SI30 -	120/ 15 20/ 15	- SI30 -	200/ 13 50/ 2 40/ 2 30/ 3 20/ 68	3	0
15-B	120/ 20	- SI30 -	160/ 16 40/ 2 30/ 3 20/ 34	- SI30 -	160/ 15 30/ 1 20/ 48	3	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
16-B	160/ 20 40/ 2 30/ 2 20/ 4	- SI30 -	120/ 25 20/ 40	- SI30 -	120/ 16 20/ 40	4	0
17-B	200/ 20 70/ 1 60/ 2 50/ 2 40/ 3 30/ 2 20/ 18	- SI30 -	160/ 17 40/ 2 30/ 3 20/ 64			4	0
18-B	120/ 20	- SI30 -	120/ 20 20/ 20	- SI30 -	160/ 15 30/ 1 20/ 49	3	0
19-B	160/ 15 30/ 1 20/ 2	- SI30 -	200/ 11 50/ 2 40/ 3 30/ 2 20/ 42	- SI30 -	120/ 15 20/ 28	3	0
20-B	200/ 17 70/ 1 60/ 2 50/ 2 40/ 3 30/ 2 20/ 18	- SI30 -	200/ 15 50/ 2 40/ 2 30/ 2 20/ 68			4	0
21-B	120/ 25 20/ 2	- SI30 -	120/ 20 20/ 17	- SI30 -	200/ 13 50/ 2 40/ 2 30/ 3 20/ 67	4	0
22-B	120/ 25 20/ 2	- SI30 -	200/ 18 70/ 2 60/ 2 50/ 3 40/ 2 30/ 7 20/ 68			4	0
23-B	200/ 17 70/ 1 60/ 2 50/ 2 40/ 3 30/ 2 20/ 18	- SI30 -	200/ 15 50/ 2 40/ 2 30/ 2 20/ 68			4	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
24-B	160/ 25 50/ 2 40/ 2 30/ 3 20/ 6	- SI30 -	160/ 22 50/ 2 40/ 3 30/ 4 20/ 79			4	0
25-B	120/ 25 20/ 2	- SI30 -	200/ 18 70/ 2 60/ 2 50/ 3 40/ 2 30/ 7 20/ 68			4	0
26-B	160/ 20 40/ 2 30/ 2 20/ 4	- SI30 -	200/ 18 70/ 2 60/ 2 50/ 2 40/ 2 30/ 12 20/ 72			3	0
27-B	200/ 22 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 2 20/ 47	- SI30 -	120/ 20 20/ 40			4	0
28-B	160/ 25 50/ 2 40/ 2 30/ 3 20/ 6	- SI30 -	160/ 22 50/ 2 40/ 3 30/ 4 20/ 79			4	0
29-B	160/ 15 30/ 1 20/ 2	- SI30 -	200/ 23 80/ 2 70/ 3 60/ 2 50/ 3 40/ 7 30/ 12 20/ 81			4	0
30-B	200/ 15 50/ 1 40/ 2 30/ 3 20/ 4	- SI30 -	120/ 20 20/ 28	- SI30 -	120/ 16 20/ 41	4	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
31-B	120/ 25 20/ 2	- SI30 -	120/ 15 20/ 2	- SI30 -	200/ 13 50/ 2 40/ 2 30/ 3 20/ 68	4	0
32-B	160/ 15 30/ 1 20/ 2	- SI30 -	200/ 23 80/ 2 70/ 3 60/ 2 50/ 3 40/ 7 30/ 12 20/ 81			3	0
33-B	120/ 20	- SI30 -	200/ 23 80/ 2 70/ 3 60/ 2 50/ 3 40/ 4 30/ 12 20/ 79			3	0
35-B	200/ 17 70/ 1 60/ 2 50/ 2 40/ 3 30/ 2 20/ 18	- SI30 -	200/ 15 50/ 2 40/ 2 30/ 2 20/ 68			4	0
36-B	120/ 15	- SI30 -	120/ 15	- SI30 -	160/ 22 50/ 2 40/ 3 30/ 2 20/ 68	4	0
37-B	200/ 22 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 2 20/ 47	- SI30 -	120/ 20 20/ 40			4	0
38-B	120/ 15	- SI30 -	160/ 21 50/ 2 40/ 3 30/ 2 20/ 42	- SI30 -	120/ 20 20/ 40	3	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
40-B	120/ 20	- SI30 -	160/ 15 30/ 2 20/ 14	- SI30 -	120/ 21 20/ 53	4	0
41-B	120/ 20	- SI30 -	120/ 25 20/ 20	- SI30 -	200/ 13 50/ 2 40/ 2 30/ 3 20/ 67	3	0
42-B	160/ 20 40/ 2 30/ 2 20/ 4	- SI30 -	200/ 18 70/ 2 60/ 2 50/ 2 40/ 2 30/ 12 20/ 72			4	0
43	120/ 25 20/ 2	- SI30 -	120/ 25 20/ 30	- SI30 -	120/ 25 20/ 53	23	0
44	160/ 25 50/ 2 40/ 2 30/ 3 20/ 6	- SI30 -	160/ 25 50/ 2 40/ 3 30/ 4 20/ 79			14	0
45	80/ 110					7	0
46	80/ 130					24	0

Profile #	Dv 1		Dv 2		Dv 3		Dv 4		Dv 5	# Exposures	# DCS
47	80/25	- SI30 -	80/25	- SI30 -	80/25	- SI30 -	80/25	- SI30 -	80/25	12	0

Phase II.

Profile #	Dive 1	Dive 2	Dive 3	# Exposures	# DCS
II.1	120/ 60 30/ 7 20/ 60			14	0
II.2	140/ 20 20/ 7			9	0
II.3	140/ 45 40/ 6 30/ 7 20/ 52			8	0
II.4	160/ 20 20/ 13			8	0
II.5	160/ 45 60/ 2 50/ 8 40/ 7 30/ 7 20/73			10	0
II.6	180/ 15 20/ 11			7	0
II.7	180/ 40 70/ 2 60/ 7 50/ 7 40/ 7 30/ 7 20/ 79			11	0
II.8	200/ 15 40/ 1 30/ 1 20/ 14			4	0
II.9	200/ 35 160/ 1 140/ 1 100/ 1 70/ 6 60/ 7 50/ 7 40/ 7 30/ 7 20/ 87			4	0

Profile #	Dive 1	Dive 2	Dive 3	# Exposures	# DCS
II.10	220/ 15 60/ 2 50/ 2 40/ 2 30/ 3 20/ 5			13	0
II.11	220/ 25 100/ 1 90/ 2 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 8 20/ 64			12	1
II.12	220/ 35 120/ 1 110/ 2 100/ 2 90/ 3 80/ 3 70/ 1 60/ 2 50/ 11 40/ 12 30/ 12 20/ 104			7	0
II.13	240/ 15 70/ 2 60/ 2 50/ 2 40/ 3 30/ 2 20/ 16			12	0
II.14	240/ 20 90/ 2 80/ 3 70/ 2 60/ 2 50/ 2 40/ 3 30/ 2 20/ 54			8	0

Profile #	Dive 1	Dive 2	Dive 3	# Exposures	# DCS
II.15	240/ 25 110/ 2 100/ 2 90/ 3 80/ 2 70/ 2 60/ 3 50/ 2 40/ 7 30/ 11 20/ 79			8	0
II.16	260/ 15 80/ 2 70/ 2 60/ 3 50/ 2 40/ 2 30/ 3 20/ 31			4	0
II.17	260/ 25 120/ 3 110/ 3 100/ 2 90/ 2 80/ 2 70/ 2 60/ 2 50/ 7 40/ 12 30/ 12 20/ 95			3	0
II.18	280/ 15 90/ 3 80/ 2 70/ 2 60/ 2 50/ 3 40/ 2 30/ 2 20/ 47			20	0

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
II.19	280/ 20 120/ 1 110/ 3 100/ 3 90/ 2 80/ 2 70/ 3 60/ 1 50/ 2 40/ 9 30/ 12 20/ 80					8	1
II.20	300/ 15 100/ 3 90/ 2 80/ 2 70/ 3 60/ 2 50/ 2 40/ 2 30/ 5 20/ 60					8	0
II.21	300/ 20 130/ 1 120/ 4 110/ 2 100/ 2 90/ 3 80/ 2 70/ 2 60/ 2 50/ 7 40/ 12 30/ 12 20/ 95					7	0
II.22	120/ 30 20/ 8	- SI30 -	120/ 35 30/ 4 20/ 62	- SI30 -	120/ 25 20/ 53	10	0
II.23	100/ 15	- SI180 -	100/ 30	- SI180 -	120/ 30 20/ 39	8	0
II.24	120/ 35 20/ 12	- SI30 -	100/ 35 20/ 52			8	0
II.25	140/ 35[1] 30/ 3 20/ 16	- SI30 -	120/ 30 30/ 1 20/ 62			6	0

[1] Profile II.25 was computed with first dive as 140/30, but dove with first dive as shown due to typographical error.

Profile #	Dive 1		Dive 2		Dive 3	# Exposures	# DCS
II.26	140/ 30 30/ 3 20/ 16	- SI180 -	140/ 30 30/ 5 20/ 60			5	0
II.27	140/ 20 20/ 7	- SI30 -	140/ 30 40/ 4 30/ 7 20/ 57			7	0
II.28	160/ 30 40/ 4 30/ 7 20/ 31	- SI30 -	160/ 25 40/ 2 30/ 7 20/ 74			8	0
II.29	120/ 25 20/ 4	- SI180 -	160/ 20 30/ 3 20/ 32	- SI30 -	140/ 15 20/ 42	6	3[2]
II.30	160/ 25 30/ 6 20/ 15	- SI180 -	120/ 35 20/ 57			8	0
II.31	140/ 20 20/ 7	- SI30 -	160/ 30 50/ 5 40/ 7 30/ 7 20/ 70			7	0
II.32	180/ 25 40/ 6 30/ 7 20/ 29	- SI180 -	160/ 30 40/ 4 30/ 7 20/ 72			6	0
II.33	180/ 20 30/ 6 20/ 14	- SI180 -	180/ 35 60/ 7 50/ 7 40/ 7 30/ 7 20/ 95			7	0
II.34	180/ 20 30/ 6 20/ 14	- SI30 -	180/ 25 60/ 2 50/ 7 40/ 7 30/ 7 20/ 80			11	1

[2] This profile is outside the recommended limit of only one repetitive dive after a decompression stop dive (*c.f.*, item 3 in Conclusions and Recommendations).

Profile #	Dive 1		Dive 2	Dive 3	# Exposures	# DCS
II.35	200/ 20 140/ 1 100/ 1 60/ 1 50/ 6 40/ 7 30/ 7 20/ 47	- SI30 -	180/ 25 40/ 6 30/ 6 20/ 84		3	0
II.36	200/ 15 40/ 1 30/ 1 20/ 14	- SI180 -	180/ 35 60/ 7 50/ 7 40/ 7 30/ 7 20/ 91		8	0
II.37	200/ 20 100/ 1 70/ 1 40/ 4 30/ 7 20/ 24	- SI30 -	180/ 15 30/ 4 20/ 57		6	0